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ABSTRACT

This module brings together in a panel discussion opposing views and supporting data on the first Philippine nuclear power plant in Morong, Bataan. It extends the discussion of issues and ideas about nuclear power in the dialogue "Go Nuclear" (which should be read before starting this panel discussion). The module deals with the environmental, health, technical, geographic, social, economic, and political aspects of the nuclear power plant. Views of an environmentalist, student, professor, and experts on nuclear plant operations and monitoring are presented. The pros and cons are discussed under each of the following headings: (1) environmental and health impact; (2) safety of plant design; (3) characteristics of plant location; (4) waste control and management; and (5) economic and political implications. Brief comments for the student and for the teacher are provided. The material in the module is recommended for college students in a physics course or a science class looking at the influence of science and technology on society. (JN)

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SCIENCE

No more obstacle to nuclear plant

AP-A1 J. AMOR

THREE GROUPS in the Philippines are working to the completion of the Philippine government's plan to build a nuclear plant.

One is the Philippine Nuclear Power Plant, Inc. (PNPI), a government-owned corporation. Another is the Philippine Nuclear Power Plant, Inc. (PNPI), a government-owned corporation. The third is the Philippine Nuclear Power Plant, Inc. (PNPI), a government-owned corporation.

Ignorance breeds unfounded nuke fears

New row arises over nuke plant

Bataan 'fallout'

IN BATAAN, the country's largest island, a new row has arisen over the proposed nuclear power plant. The controversy is centered on the possibility of fallout from the plant, which is located in the Bataan Peninsula.

US okays nuclear plant for RP

THE US Nuclear Regulatory Commission has approved the proposed nuclear power plant for the Philippines. The commission's decision was based on the fact that the plant meets all the necessary safety requirements.

Safety of nuke plant doubted

Westinghouse N-plant safe

Westinghouse Nuclear Corporation has stated that its proposed nuclear power plant is safe. The company has provided detailed information about the plant's safety features.

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TO THE EDUCATIONAL RESOURCES INFORMATION CENTER (ERIC).

We needn't go nuclear

By D. C. AMOR

The proposed nuclear power plant in Bataan is a costly and risky venture. There are many other ways to generate electricity that are safer and more economical.

Nuclear plan energy progr

By Eusebio S. Lopez

The government's nuclear energy program is a bold step towards energy independence. It will help to reduce the country's reliance on foreign oil.

Science and Technology Education in Philippine Society

SE 046264

cover photo: news items from bulletin today, september 17, 1979, december 29, 1980
march 20, 1981, and times journal, october 2, 1979, november 15, 1979, may 8, 1980
december 18, 1980, march 20, 1981

NUCLEAR POWER: Pros and Cons



This is one of a series of science modules prepared by the University of the Philippines Institute for Science and Mathematics Education Development (ISMED) supported by the Educational Development Projects Implementing Task Force (EDPITAF).

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CREDITS

Figures 1-2 — National Power Corporation

Figure 4 — Philippine Institute of Volcanology

TO THE READER

Nuclear Power: Pros and Cons brings together in a panel discussion opposing views and supporting data on the first Philippine Nuclear Power Plant in Morong, Bataan. It extends the discussion of issues and ideas about nuclear power in the dialogue, *Go Nuclear?* It is suggested that the dialogue be read before the panel discussion.

The discussion deals with the environmental, health, technical, geographic, social, economic and political aspects of the nuclear plant. Views of an environmentalist, student, professor, and experts on nuclear plant operations and monitoring are presented. The pros and cons are discussed under each of the following headings:

1. Environmental and Health Impact
2. Safety of Plant Design
3. Characteristics of Plant Location
4. Waste Control and Management
5. Economic and Political Implications

You can get the most out of the panel discussion by listing the pros and cons for each topic. Supplement the list using other sources. Test your decision-making skill by asking whether or not you will support another nuclear power plant for the country. Explain your decision.

It is hoped that your opinions and decisions about the nuclear plant will be based on an objective comparison of the pros and cons of nuclear power.

TO THE TEACHER

This panel discussion on nuclear power is recommended for college students in a physics course or a science class looking at the implications of science and technology to society. To prepare students for the panel discussion, let them read the dialogue in this series, entitled, *Go Nuclear?*

Selected students can be asked to play the roles of the members of the panel. Since the panel discussion is somewhat long, the panelists can be seated facing the class. To hold the attention of the audience, instruct the panelists to read the lines with feelings associated with their stand.

The diagrams and tables can be placed on charts or the blackboard, and the panelist concerned can stand up and refer to the diagram or table to stress a point. The panelists can present additional data, diagrams, tables, photographs to further explain their views.

Ask the students in the audience to summarize and write the arguments for and against a nuclear plant under each topic as the panelists present their opinions.

An open forum can follow the panel discussion with students in the audience asking questions or giving comments. Encourage the students to supplement the discussion from their other readings.

After the discussion, the students' individual lists can be consolidated on the blackboard. Stress the importance of forming one's opinion on the basis of data and facts, rather than on the opinions of friends, peers, teachers or some other authority. Emphasize the need to gather as many data and facts as possible and to weigh the pros against the cons of an issue before making opinions and decisions. Point out, too, the need to evaluate the reliability of the sources of data.

This lesson, in addition to presenting facts, data and opinions for a total picture of the Bataan nuclear plant, aims to develop communication and decision-making skills in the students.

The data in this panel discussion were the latest available when the script was written. Modify the script to update the information and to suit the conditions of your school and students. For continuous updating of data, collect news clippings and magazine articles about the nuclear plant. For additional information, write to: The Commissioner, Philippine Atomic Energy Commission, Don Mariano Marcos Avenue, Diliman, Quezon City.

Nuclear Power: Pros and Cons

In a university hall some college students are gathered to listen to a panel of experts discuss the varying opinions and issues about the nuclear power plant in Morong, Bataan. Moderating the panel discussion is Miss Josefa Magtanggol.

(The names used for the moderator and members of the panel are fictitious.)

Magtanggol : Our panel discussion today is about a controversial topic — the first Philippine Nuclear Power Plant. The points raised for and against the nuclear plant will be discussed. Hopefully, our discussion will be able to present answers to some questions raised by the public:

1. Is the nuclear power plant an economic necessity to a developing country like the Philippines?
2. What risks are involved in the operation of the nuclear plant?
3. What were the political considerations in the decision to construct the power plant?
4. What are the social and environmental effects of the construction and operation of this plant?

Let me give a short background of our nuclear power plant.

Nuclear power plants were built to meet the foreseen need for a large-scale source of energy besides oil. The first full scale nuclear-electric generating plant was constructed in 1957 in Pennsylvania, United States. Since then public opinion has shifted from a general acceptance to that of strong criticism of the nuclear power plant. Doubts are now cast about the capability of the current nuclear technology, the economics of the nuclear power plant and the integrity of the political machinery that safeguards the health and safety of the public.

With the memories of Hiroshima and Nagasaki in Japan still lingering in the minds of the people, many believe that the nuclear power plant is a threat to existing and future generations. On the other hand, nuclear proponents say that the economic benefits far outweigh the societal risks. There were 294 nuclear power reactors in operation in the world at the end of 1982. Table 1 shows the number of nuclear plants in operation and under construction in different countries. Japan, where the atomic bombs were dropped, has 25 nuclear plants in operation. Proponents maintain the optimism for nuclear power, believing that there is no problem in nuclear power development that science and technology will not find answers to.

In the Philippines, two studies on the economic feasibility of putting up a nuclear power plant in Luzon were made between 1964 to 1973. In 1968, the Atomic Energy Regulatory and Liability Act instituted procedures for licensing and regulating the construction and operation of a nuclear power plant. In 1972, under Republic Act 3165, the National Power Corporation (NPC) was authorized to establish and operate nuclear plants. In 1973, a presidential order was signed for the establishment of the first nuclear power plant in Bataan with the NPC as the operator. Westinghouse International Projects Company was chosen to provide the equipment and construction plans. Construction started in 1977.

In 1979, the needed funds for the construction of nuclear plant were guaranteed by the United States Export-Import Bank. In April 1979, the Philippine Atomic Energy Commission (PAEC) granted full permit to the National Power Corporation to construct the first Philippine Nuclear Power Plant.

Opposition to this plant urged the President of the Philippines to suspend the construction in June 1979. A commission was created to look at the safety to the public of the Bataan nuclear plant. Public hearings were conducted, and the Commission released its findings in November 1979. It concluded that the site

Table 1
Nuclear Power Reactors in Operation
and Under Construction at the End of 1982*

	In operation		Under construction	
	Number of units	Total MW (e)**	Number of units	Total MW (e)**
Argentina	1	335	2	1 291
• Belgium	5	3 463	2	2 012
Brazil	1	626	2	2 490
• Bulgaria	4	1 632	1	1 000
• Canada	13	6 686	10	6 772
"China, Republic of"	4	3 110	2	1 814
Cuba			1	408
• Czechoslovakia	2	762	6	2 520
• Finland	4	2 160		
France	32	23 355	27	30 200
• German Democratic Republic	5	1 694	8	3 276
• Germany, Federal Republic of	15	9 831	9	9 411
• Hungary	1	408	3	1 224
India	4	809	3	1 320
• Italy	3	1 232	3	1 999
• Japan	25	16 589	10	9 233
Korea, Republic of	2	1 193	7	6 227
• Mexico			2	1 308
• Netherlands	2	501		
Pakistan	1	125		
• Philippines			1	620
• Poland			1	440
• Romania			2	1 320
South Africa			2	1 842
Spain	4	1 973	11	10 156
• Sweden	10	7 330	2	2 110
• Switzerland	4	1 940	1	942
Union of Soviet Socialist Republics	40	17 876	23	23 420
United Kingdom	31	6 470	10	6 292
United States of America	80	62 376	61	67 213
• Yugoslavia	1	632		
World Total	294	173 108	215	196 860

Construction in Austria and Iran has been interrupted and plants in these countries are not included.

*Source: International Atomic Energy Agency Bulletin. Vol. 25, No. 1, March 1983.

**MW (e) = megawatt electrical; 1 megawatt = 1 000 000 watts

• Non-nuclear weapon States party to the Treaty on Non-Proliferation of Nuclear Weapons, where the safeguards agreement were in force as of November 1982.

was acceptable but required additional safety features to be incorporated into the design of the Westinghouse Plant.

The additional safety features and construction delay resulted in an increase in the cost of the plant from \$1.1 B to \$1.9 B. Construction of the plant resumed in September 1980. The plant is expected to be in commercial operation by 1985. However, opposition to this plant continues.

Our distinguished panel will shed light on some issues about the Bataan plant. I would like to introduce the members of our panel:

Engineer Jose Paez, an expert on regulations and safeguards of nuclear power plants;

Engineer Julian Reyes, an expert on nuclear power plant operations;

Mr. Nicanor Fredo, a civic leader in our community who is concerned with the environmental effects of the plant;

Dr. Estela Cruz, a professor of natural science in our university; and

Leonila Santos, President of our Student Council.

(The audience applauds as each member of the panel is introduced.)

We shall focus on five major issues, namely:

1. Environmental and Health Impact of the Plant,
2. Safety of Plant Design,
3. Characteristics of Plant Location,
4. Waste Control and Management,
5. Economic and Political Implications.

Before we discuss the issues, Engineer Reyes, for the benefit of our audience could you explain briefly how the Bataan plant will generate electricity?

Reyes : The operating principle is essentially the same as in other electric power plants, except that here nuclear

reactions produce the heat needed. To describe the process simply, the nuclear reactions are a series of nuclear fissions where several nuclei of uranium-235 are split, releasing radiations and tremendous heat. These reactions take place within the fuel rods. The fuel is natural uranium with about 3% uranium-235 enrichment.

Our nuclear plant is a pressurized water reactor type (refers to Fig. 1). Water under high pressure circulates through the reactor core to absorb the heat generated by the nuclear reactions. When the heated water (primary coolant) passes through the steam generator, the secondary coolant boils and steam is generated. The steam drives the turbine which runs the electric generator. The steam passing through the turbine gives up its heat to the tertiary coolant, which is water from the sea. The steam changes to water and goes back to the steam generator.

During normal operations of the plant, about 720 000 liters of seawater per minute will be pumped in as tertiary coolant. This water circulates, absorbs the heat from the steam and goes back to the sea.

There are three water systems, the primary coolant passing through the core, the secondary coolant for generating steam, and the tertiary coolant (seawater) for condensing the steam. It is important to note that the separation of the water systems prevents the release of radiations into the sea.

Environmental and Health Impact

Magtanggol : Thank you, Engineer Reyes. Perhaps we can now proceed to the issues. One controversial point is about the adverse environmental and health effects of the operation of a nuclear plant. Would you like to comment on this, Engineer Paez?

Paez : Nuclear power plant operation poses a small degree of risk to the public. During normal operations, minimal amounts of radiation and thermal heat are released

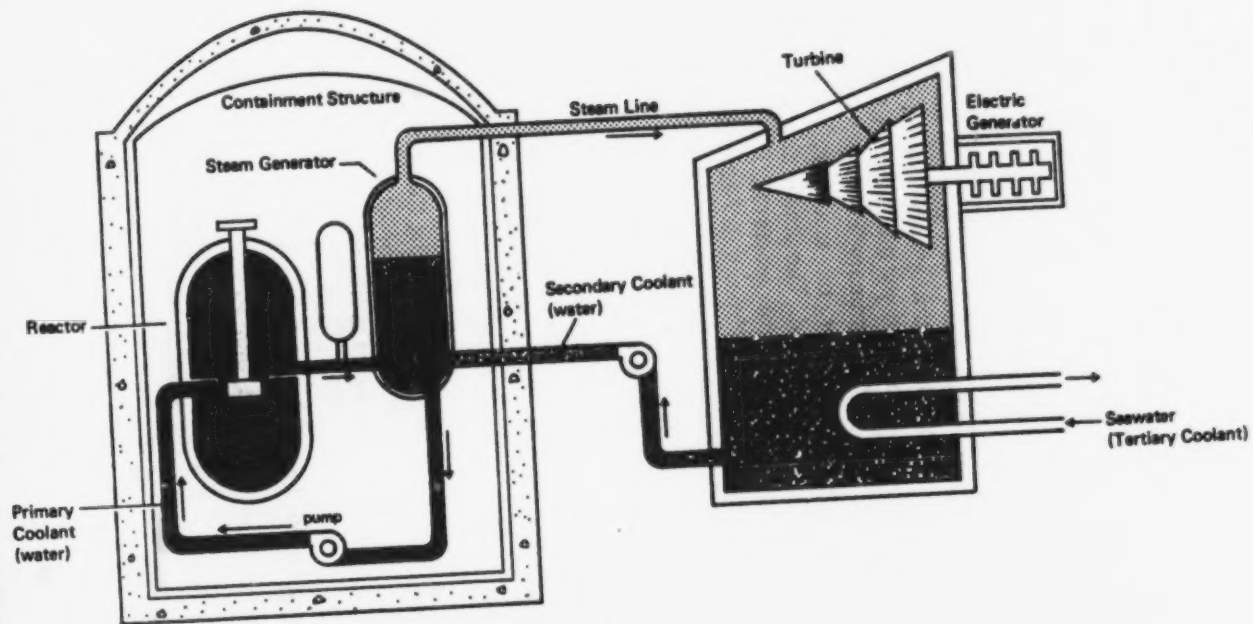


Fig. 1. Typical Diagram of a Pressurized Water Reactor Plant like the Bataan Nuclear Power Plant

to the environment. However, other energy sources have far greater adverse effects to the environment and the public than the nuclear plant.

The geothermal plants release through a stream highly mineralized waste water and hydrogen sulfide. Coal-fired plants discharge sulfur dioxide and other related pollutants and particulates into the atmosphere. Studies have related these substances with respiratory and lung diseases.

- Fredo : What about thermal heat? Heated water discharged from the Bataan plant to the nearby rivers and seas may result in the death of some important and economically profitable species of aquatic animals. Thermal pollution from the nuclear plant will affect the feeding and reproduction habits of fish and photosynthesis in aquatic plants.
- Paez : But this is also true with other thermal-electric plants fired by oil or coal. In the case of our own nuclear plant, the heated water from the plant will be discharged into the South China Sea.
- Fredo : Then it will definitely affect seriously the aquatic life in that part of the South China Sea.
- Paez : The rise in temperature of the seawater 5 to 10 meters away from the outlet of the plant is 5.5°C. Some species of fish will simply migrate to a more suitable environment. Other species, however, may be attracted to the warm water near the site.
- Santos : I think one important and unique characteristic of the nuclear power plant is the production of radioactive elements which have longer and greater adverse effects than the particulates and pollutants from other plants. What are the radioactive elements produced during a normal nuclear plant operation?

- Paéz** : A reactor like our nuclear plant, normally, produces strontium-90, cesium-137, barium-140 and iodine-131. These elements can cause cancer. However, nuclear plants are designed to limit within tolerable amounts the release of these elements to the environment so that they will not pose hazards to the public.
- Reyes** : The Bataan plant, specifically, has a containment vessel which is equipped with features to filter radioactive products of the nuclear fissions. The radioactive materials in liquid and gaseous forms will be diluted to the lowest radioactivity level possible when released to the environment. Radiation due to normal plant releases is very low compared to radiation from other sources.
- Cruz** : How low should these radiation releases be?
- Paéz** : As low as the standards set by the Philippine Atomic Energy Commission. These standards are based on the United States Environmental Protection Agency standards. The maximum overall public exposure is 25 millirems a year above the normal background exposure. Normal radiation background from the earth, sun and outer space is about 120 millirems a year. Rem is the unit of absorbed dose considering the biological response and characteristics of different radiations.
- Santos** : If the radiation dose is below this standard, will there be absolutely no radiation health hazards to the public?
- Paéz** : It is impossible to have zero releases from nuclear plants as it is to have zero releases of pollutants from any industrial process. What can be done is to assure that any releases are well below the levels giving rise to significant environmental or human health effects.
- In the United States, the current levels of releases from nuclear plants may shorten life span by 24 sec-

onds. In contrast, being 25% overweight decreases life span by 3.6 years. Smoking a pack of cigarettes a day can decrease life span by 7 years, and living in the city rather than in the rural areas, by 5 years.

Fredo : Some scientists agree that low doses of radiation can cause cancer. Even a small amount of some radioactive elements may continue to produce effects for hundreds and even thousands of years.

Cruz : Even in the absence of a major nuclear accident, cancer deaths may directly result from operations of the nuclear industry.

The United States Nuclear Regulatory Commission estimates that 1100 cancer deaths between 1975 and 2000 may be attributed to the nuclear power industry. A report of the United States National Academy of Science entitled, "Risks Associated with Nuclear Power", indicates 2000 additional cancer deaths due to the use of nuclear power in the same period. Both studies assume low dose of radiation exposure, that is, no major nuclear accident has occurred.

Paez : The extent of the effect of low-level radioactive emissions is still under study. The best estimate, without a major nuclear accident, is 40 to 80 cancer deaths a year. This is insignificant compared to approximately 360 000 cancer deaths a year from other causes.

Reyes : The estimates pointed out by Dr. Cruz are based on several nuclear power plants in the United States. The estimates also include radiation exposure in the mining and milling of uranium, fabrication, reprocessing and storage of nuclear fuel. Cancer deaths due to the operation of a single plant such as ours will be minimal. Besides, we do not mine uranium, fabricate nuclear fuel or reprocess used fuel.

Safety of Plant Design

Magtanggol : Scientists may disagree on the effects of low radiation. However, they do agree that abnormally high releases of radiation will have severe effects on the population. This high-level radiation release is likely to occur during accidents. The safety of a nuclear plant, therefore, depends on how these accidents can be prevented.

Engineer Reyes, what actions or measures are usually adopted to prevent accidents in a nuclear plant?

Reyes : The safety of plant design must be assured. The requirements include the following:

1. The plant components must be able to withstand natural calamities like earthquakes and volcanic eruption.
2. The plant design must provide continuous or regular monitoring to detect and correct failure of its parts, for example, valves, pumps, switches, cooling systems.
3. The design must be able to handle abnormal conditions like extremely high temperature and pressure.
4. The plant must have automatic controls and safety features to prevent nuclear accidents.

Fredo : Does our nuclear plant design meet all these requirements, Engineer Reyes?

Reyes : I believe so. For example, this chart (referring to Figure 2) shows the multiple protective barriers of the reactor in the plant. The reactor is inside a 12.7 cm thick carbon steel vessel. The vessel is surrounded by a thick concrete wall. The vessel and wall are further housed in a 2.5 cm thick carbon steel shell. Finally, the shell is enclosed by a steel-reinforced concrete wall about 1 meter thick. The concrete floor is about 6 meters thick.

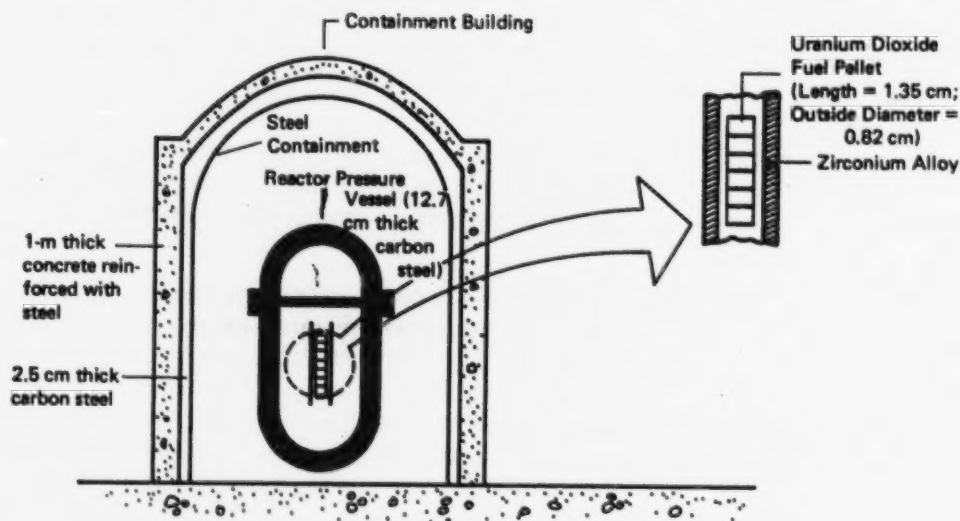


Fig. 2. Protective Barriers of the Bataan Nuclear Reactor

Table 2. Chances of Death from Accidents or Natural Calamities*

Event	Chance of 100 or more Deaths
Airplane Crash	1 in 2 years
Fire	1 in 7 years
Explosion	1 in 16 years
Earthquake	1 in 20 years
Nuclear Power Plants (100 plants)	1 in 10 000 years

*Source: Dawson, Frank F. *Nuclear Power: Development and Management of Technology*. Washington: University of Washington Press, 1976.

This structure can withstand the most powerful typhoon, a tsunami hit, a major earthquake, and even a direct hit by a jet liner.

Cruz : How will our plant cope with abnormal conditions like extremely high temperature and a nuclear accident like meltdown or the melting of its core?

Reyes : Although a meltdown is unlikely, the Bataan Nuclear Plant is provided with features to cope not only with meltdown but also with other types of emergency. For example, the Emergency Core Cooling System ensures a sufficient supply of water for the extraction of excess heat from the core. A cooling tower will provide additional water in case of emergency.

Santos : What happens in a meltdown? Why is there a need for water or a coolant?

Reyes : When there is no cooling water, excess heat from the nuclear reactions builds up and affects the fuel rods.

The fuel of our plant is in the form of uranium dioxide pellets (referring to inset of Figure 2). The pellets are stacked in a tube made of zirconium alloy.

Intense heat could melt the zirconium tube and expose the uranium pellets. The fuel in turn could melt and leak through the concrete floor into the ground below. Radioactive gases rising from the melted fuel could escape into the atmosphere with widespread effects. But the chance of a meltdown happening is very unlikely, one in 20 000 reactor years.

Cruz : I read about nuclear accidents between 1952 and 1979 mostly in the U.S. ranging from release of radiation, escaping steam, failure of fuel rods to near meltdown. A well-publicized accident was the near meltdown in Three-Mile Island, Pennsylvania in 1979.

- Paez : But none of the accidents was a meltdown. In the case of the Three-Mile Island accident, sensational news reporting created more damage to the public than the radiation released. Chances of death and injuries from nuclear plants are quite small. If we look at this table (referring to Table 2) chances of death from airplane crash, fire, explosion, and earthquakes are much greater.
- Reyes : It should also be mentioned that in case of a nuclear accident, there is an emergency action plan that includes procedures for notifying the public, emergency first aid, and personal decontamination procedures.
- Fredo : One criticism of our nuclear plant is the lack of Filipino experts to operate the plant and monitor its safety. What is being done about this, Engineer Paez?
- Paez : Since 1976, a number of Filipino engineers have been sent to a Westinghouse training plant in the U.S.A. Our nuclear engineers were earlier trained by the United States Nuclear Regulatory Commission in different American nuclear power plants. Some received their training in Europe.
- Reyes : In the United States, high school graduates may become operators or supervisors of nuclear power plants. Our operators are Bachelor of Science in Engineering graduates who are trained and certified in the United States.
- Fredo : The certification does not guarantee sufficient competence to operate the plant without foreign experts.
- Santos : Just for clarification, the National Power Corporation takes care of the construction and operations of the plant. What is the function of the Philippine Atomic Energy Commission besides giving the construction permit?

Paetz : The Philippine Atomic Energy Commission licenses and regulates the construction and operations of the nuclear plant to ensure that requirements and standards are met for public safety. Quite a number of PAEC personnel are already trained, and some are undergoing advanced training on various areas of nuclear regulation.

Characteristics of Plant Location

Magtanggol : We considered some aspects of plant design like the multiple protective barriers. We also touched on nuclear accidents and our nuclear expertise. The safety of plant design also depends on the characteristics of the location of the plant. Engineer Reyes, where exactly is the Philippine Nuclear Power Plant?

Reyes : This map (referring to Figure 3) shows the location of the plant in Morong, Bataan overlooking the South China Sea.

Fredo : If you look at the map (referring to Figure 3), the Nuclear Power Village where the plant employees live is in Bagac, about 17 kilometers away. In the United States and Europe, housing of key personnel is usually next to the power plant. Some accidents develop in seconds or minutes and require immediate action.

Reyes : Originally, the site for the nuclear plant was in Bagac. When the plant site was changed to Napot Point, some of the houses were already constructed. A substantial amount of money was saved by retaining the Bagac housing.

Santos : What were the considerations made in the choice of this site?

Reyes : First, the site should be such that the nuclear plant can be conveniently tied up with the other power plants in Luzon. We also had to consider certain as-

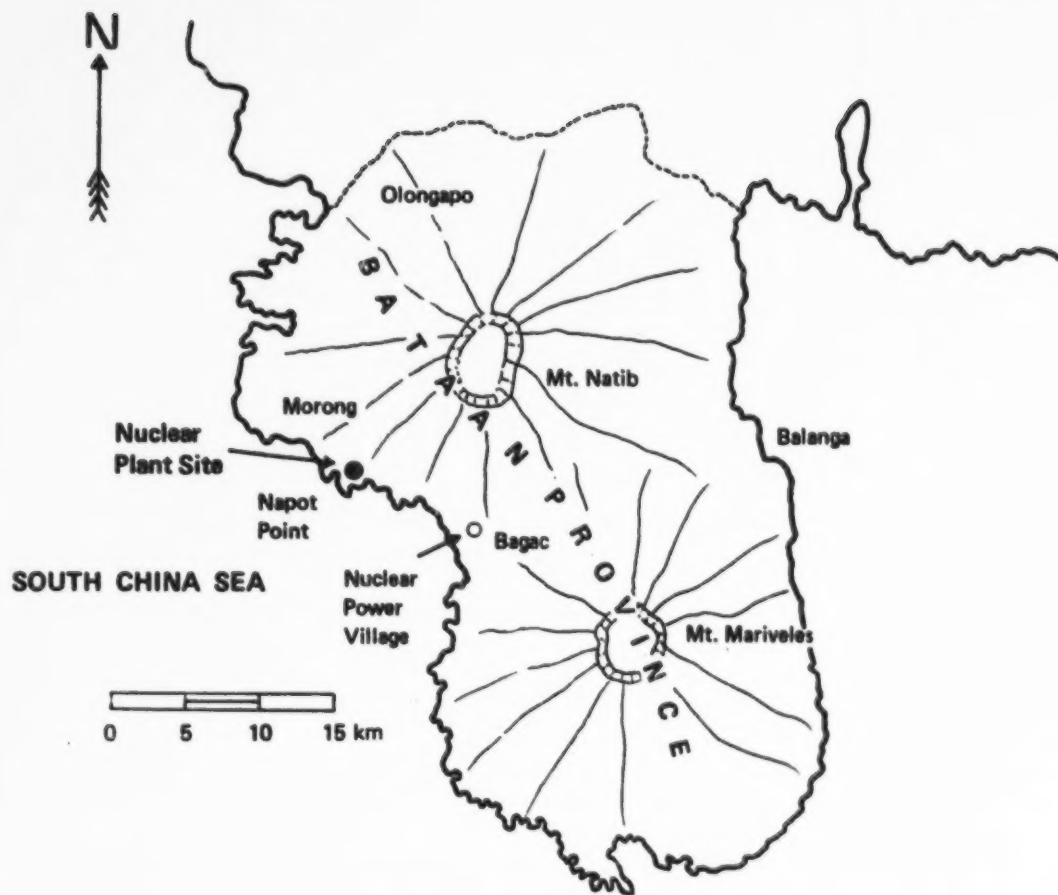


Fig. 3. Location of the Bataan Nuclear Power Plant

pects like the presence of a large body of water, the possibility of earthquake hits, volcanic eruptions, and tsunamis or giant sea waves in the area. The social impact was also considered.

- Paez : According to the International Atomic Energy Agency Siting Mission that came here to study the plant site, the most important consideration in the siting and design of the Bataan plant was the possibility of earthquakes. Bataan has low incidence of earthquakes compared to other regions in the Philippines.
- Cruz : The Philippines lies on the Circum-Pacific Belt of Fire — the source of destructive earthquakes in the west coast of South and North America, Northern Pacific and Japan. Near the plant site are faults from which earthquakes may originate. For example, the Manila Trench is 100 kilometers from the site (referring to Figure 4) and the shorter West Luzon Trough is only 30 kilometers away.
- Reyes : Several nuclear plants were constructed in places where earthquakes are common like Japan and California, U.S.A. The Bataan plant is designed to withstand earthquakes that will cause horizontal motion with a maximum acceleration of 0.4 g, that is, 40% of the acceleration due to gravity, or a change of speed of about 4 meters per second every second. It is estimated that the strongest earthquake that will be felt at the site from any of the faults nearby will cause a horizontal acceleration less than 0.4 g.
- Paez : Studies on the site failed to reveal an active fault within 10 km of Napot Point, from which a large earthquake of magnitude 7 or 8 on the Richter scale could originate.
- Cruz : The magnitude of an earthquake is not necessarily related to the value of horizontal acceleration produced. For example, an earthquake in California in 1972 had

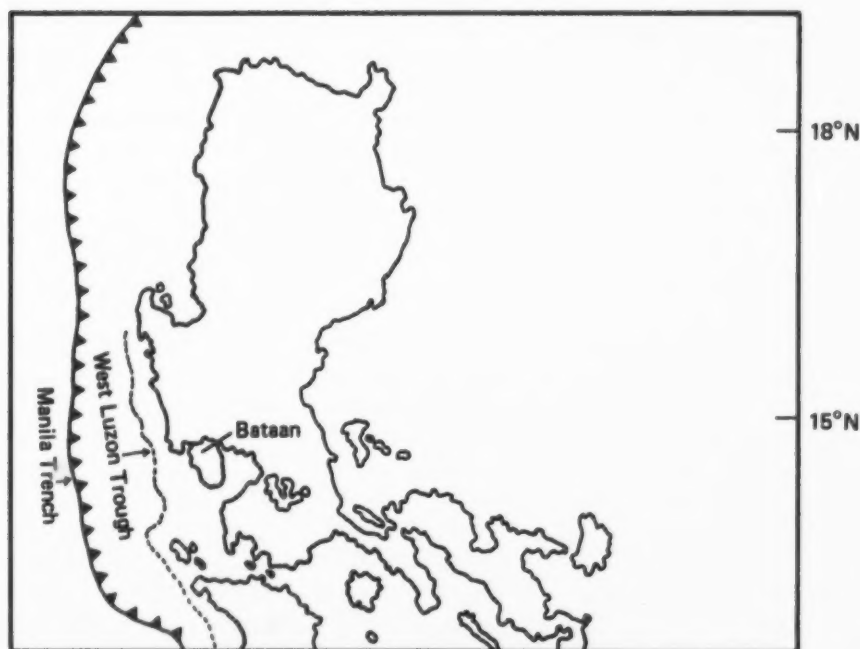


Fig. 4. Two Fault Systems Near the Bataan Nuclear Plant

a magnitude of 4.7 and produced an acceleration of 0.69 g. The duration of strong shaking and its effect on the plant should also be considered.

Reyes : Our Commission on Nuclear Reactor Plants stated that the experts' opinion on this matter is that the plant design value of 0.4 g is high enough. Increasing it further would only make the plant overdesigned and result in unnecessary expense of thousands of dollars.

Fredo : The danger of earthquakes cannot be discounted completely. How about the presence of volcanoes? Bataan was formed by the union of two non-extinct volcanoes, Mt. Natib and Mt. Mariveles (referring to Figure 3). A thermal spring at the foot of Mt. Natib is a sign that it is not extinct. Mt. Natib may erupt again.

- Cruz** : According to the International Atomic Energy Agency, the Bataan plant is the only nuclear plant located 9 kilometers away from a volcano, namely, Mt. Natib. The only modern nuclear plant designed to account for volcanic eruption is the Pebble Springs Plant in the United States located 128 kilometers from the nearest volcano.
- Reyes** : The last activity of the two volcanoes was over 70 000 years ago. Should the nearer volcano, Mt. Natib, erupt again, the activity would be on the east side, not the western part where the plant is. There are sufficient natural barriers to protect the plant from mudflow, for instance. The plant would not be affected by rocks or lava flow because of the distance. The expected intensity of ashfall would not damage the plant.
- Paez** : Unlike an earthquake that can occur without warning, the shortest period for a volcano to show activity is three days before its eruption. The Philippine Atomic Energy Commission requires a monitoring system at the plant site to predict volcanic activity. This warning period allows safeguards to be taken.
- Santos** : Is the plant also protected from tsunamis?
- Reyes** : Based on the largest possible earthquake at the Manila Trench, the maximum height of a tsunami that could hit Napot Point is 16.5 meters. The plant site is about 18 meters above sea level.
- Santos** : Engineer Reyes, you mentioned social impact as part of the assessment of plant site. What specifically do you mean by this?
- Reyes** : The plant site should be such that in case of a nuclear accident, the least number of people is affected. For this reason, the Philippine Atomic Energy Commission requires a minimum distance of one kilometer between the plant site and a low population area. The

plant is 2.2 km from the nearest barrio of Gantuan which had only 221 residents in 1981. The nearest population center is Olongapo which is 22 km from the site.

- Fredo : Morong is 10 km away. Will the residents in this place not matter? Part of social impact is the number of farmers and fishermen who were dislocated from their farm lands and fishing grounds.
- Paez : Only a few farmers were affected, because a big part of the site was a national park. Dislocation is often a consequence of a large scale development project. It is a case of deciding between the interests of a few farmers and fishermen in Morong and the electrical power needs of the Luzon area.

Waste Control and Management

Magtanggol : Another area of concern particularly for critics of the nuclear plant is waste control and management. Engineer Reyes, could you clarify to our audience what the nuclear wastes are?

Reyes : Nuclear wastes result from various stages of nuclear energy production such as:

1. uranium mining and milling
2. production of fuel
3. nuclear plant operation
4. reprocessing of used or spent fuel

Our main concern is the waste from nuclear plant operation. The other stages are not done here.

The wastes give off radiations and come in solid, liquid and gaseous forms. Some wastes have low levels of radiation such as the gaseous wastes and contaminated clothing and reactor equipment. Others have high levels of radiation like the products of fission, for example, cesium-137 and strontium-90.

Santos : Since the wastes emit radiations, great care must be exercised in disposing of them. What are the mechanisms for safe waste disposal?

Paez : Gaseous wastes are highly diluted so that their level of radiation is very low when released to the environment. Liquid wastes, for example, used water containing radiations, are processed and placed in tanks. The solid wastes are compressed and mixed with cement and placed in sealed drums. The processing of nuclear wastes is done in the radioactive waste building in the plant site.

The wastes will be placed in a temporary storage area for a few years and then transferred to a permanent storage area. The location of these storage areas is still under study.

Cruz : The permanent storage site must have stable rock formation. Our country is in a volcanic area and its underground formation is not stable enough for permanent waste storage.

Fredo : What happens to the spent fuel?

Paez : The used fuel rods will be stored in a spent fuel pit in the plant site. The pit contains demineralized water.

Cruz : Where will the spent fuel be reprocessed?

Paez : There is no decision yet whether or not our spent fuel will be reprocessed.

Santos : What happens when spent fuel is reprocessed?

Paez : The fission products are separated and important isotopes are recovered or produced.

Cruz : One important product of reprocessing is plutonium. It is used in the production of nuclear weapons, a more controversial topic worldwide.

- Fredo : The nuclear weapon connection is one of my objections to a nuclear power plant. I cannot help thinking that the Philippines has a hidden interest to produce its own nuclear weapons. Perhaps other countries planning to have nuclear plants have the same intention. Where will this lead us to? To an unsafe future and an unsafe world.
- Paez : We are not allowed to reprocess spent fuel. Reprocessing of spent fuel is limited to countries exporting nuclear plant technology. In the United States, reprocessing of spent fuel has been stopped since 1977. If we look at the list of countries with nuclear power plants (refers to Table 1), the Philippines is one of the countries that agreed not to produce its own nuclear weapons.

Economic and Political Implications

Magtanggol : Indeed some risks are involved in an energy development project. However, it is very important that the risks are far outweighed by the economic benefits of the project. This leads us to another controversial issue of the plant, its economic and political aspects. Engineer Reyes, what factors led to the decision of putting up a nuclear plant in our country?

Reyes : One is the need to lessen our dependence on imported oil. When the plant starts commercial operation in 1985, it will supply 16% of the total energy requirements of Luzon and 5% of the country's energy requirements. About 215 million dollars a year will be saved in terms of displaced imported oil.

Another consideration is the cost of nuclear energy compared to oil. According to a 1981 study of the Ministry of Energy, the cost per kilowatt-hour of nuclear energy is 37 centavos and that of oil is 53 centavos.

- Fredo : The same study shows a lower cost per kilowatt-hour of coal, geothermal energy, and wood, as follows: ₱0.32, ₱0.28 and ₱0.24, respectively.
- Cruz : The figures are operating costs. How about the initial or capital costs? The construction cost of almost two billion dollars for the plant is exceedingly high, considering our national budget and standard of living. The money came mostly from loans from United States financial institutions.
- Fredo : The interest of these loans is substantial and must be considered, too. There are other costs to consider: cost of uranium fuel, cost of waste disposal, and cost of cleaning up or restoring radiation to safe levels in case of nuclear accidents. After 30-40 years of operation, the radiation levels at the plant will have progressively become higher and will no longer be safe for the workers themselves. The cost of reducing the radiation to safe levels before closing and sealing the plant will have to be considered, too.
- Santos : Do we have uranium reserves that we could mine?
- Paez : The Philippine Atomic Energy Commission is developing a map that will show the location and extent of possible uranium sites. One site is in the Bicol region. We still have to buy uranium fuel from other countries.
- Reyes : The United States will supply us our initial uranium requirement. Where we will get our yearly uranium supply is still being negotiated. Possible sources are Australia, Canada, and the United States.
- Fredo : If this is the case, we cannot be sure that uranium will always be cheaper than oil because the price of nuclear fuel or oil is determined by the exporting countries.

- Paetz** : Even if the price of uranium doubles or increases considerably, it will still be cheaper than oil considering the limited annual fuel supply requirements of a nuclear power plant.
- Santos** : Dr. Cruz mentioned the cost of cleaning up a plant after a nuclear accident and the cost of sealing a plant after 30-40 years of operation. What are the figures involved here?
- Paetz** : The cost of cleaning up depends on the extent of damage caused by the nuclear accident. For example, in the Three-Mile Island accident where a valve and a cooling system failed, the cost of cleaning up was around one billion dollars.
- In the case of reducing radiations from a nuclear plant to a safe level after 30-40 years of operation, the cost is estimated to be from 50 to 100 million dollars.
- Cruz** : It must be pointed out, too, that since a nuclear plant is foreign technology, foreign consultants for plant operations and monitoring need to be hired and paid over and above the construction cost.
- Reyes** : It is estimated that the plant will pay for itself from its earnings during its many years of operation.
- Fredo** : Economically, the Bataan nuclear plant has increased our dependence on foreign groups and countries. The loans increased our national debt to foreign banks. We will have to depend on other countries for the purchase of uranium and the reprocessing of spent fuel, if we decide to have it reprocessed. We will need foreign experts to help us with the plant operations and regulation. One cannot deny the effect of such economic factors on the political situation in a country.

- Paez** : The United States Nuclear Regulatory Commission issues licenses for the export of nuclear plant parts and materials, including uranium fuel. But the responsibility of assuring the necessary safeguards related to the nuclear plant construction and operation is left to the recipient country.
- Fredo** : It is possible then for a country to have an outdated plant design or one that will not pass the safety requirements of the United States.
- Reyes** : Yes. But in our case, the 1979 public hearings resulted in the updating of the plant design and addition of safety features.
- Cruz** : It is important therefore that the safety requirements of the Philippine Atomic Energy Commission are met in the operation of our nuclear plant.
- Magtanggol** : I think at this point we have covered the economic, political, social, environmental and safety aspects of the first Philippine Nuclear Power Plant. Before we end, perhaps our panel can give us some final remarks to summarize their views.
- Fredo** : Considering the environmental and the socio-economic impact of the plant construction and operation, the nuclear hazards to society and the environment, and the fact that there is no accident-proof design, I consider the nuclear plant risky and unnecessary.
We should intensify the development of alternate energy sources like hydroelectric power plant and solar energy, which I think pose less dangers to the environment. What is needed is a comparison of all the costs and benefits of alternate energy sources available to us.
- Cruz** : First, the arguments presented here and those I have read about the appropriateness of the site and the

safety of the plant design are not convincing enough. Although releases are controlled during normal operations, nuclear accidents are still a possibility.

Second, I am not convinced that the nuclear plant has economic benefits that far outweigh the possible risks involved.

Third, our capability to police our own nuclear plant depends on our level of scientific and technological development. What we have are nuclear operators trained to handle Westinghouse plants. The nuclear plant is an example of transfer of technology with insufficient understanding on our part. Our capacity to choose relevant technology is also affected by this ignorance. Unless we make an effort to really develop our science and technology, we will remain dependent on foreign technology with little protection from its negative effects.

- Reyes : Nuclear plant construction is a necessity to meet the projected increase in our energy needs. The plant is, in general, safe. The National Power Corporation engineers and employees are capable of operating the plant efficiently. There are some environmental effects but these are controlled and limited.
- Paetz : The dangers of a nuclear power plant are minimal compared to the economic benefits it can give. I am confident that the Philippine Atomic Energy Commission, the country's nuclear regulatory body, will allow the operation of the plant only if the safety requirements are met.
- Santos : I would like to thank the panel for answering my questions and clarifying many points about our nuclear plant. I can now draw up a list of pros and cons with regard to environmental and health impact, safety of plant design, characteristics of plant site, waste control and management, and finally, economic and political implications. It is only after a careful exami-

nation of these pros and cons that I can make up my mind whether I am for or against nuclear power.

Magtanggol : I would like to thank most sincerely the distinguished members of our panel, Engineer Paez, Engineer Reyes, Mr. Fredo, Dr. Cruz and Miss Santos for their valuable contributions to our discussion today on nuclear power.

(Turns to audience) How about you? Are you still for or against nuclear power? We hope our panel discussion today answered some of your questions. We hope, too, that the views presented here will stimulate further reading and discussion. Thank you for your kind attention.

(Audience applauds.)

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